MADHAV INSTITUTE OF TECHNOLOGY & SCIENCE, GWALIOR

(A Govt. Aided UGC Autonomous NAAC Accredited Institute affiliated to RGPV, Bhopal)

DEPARTMENT OF MECHANICAL ENGINEERING

FLUID MECHANICS LAB MANUAL FOR STUDENTS

VISION
“To develop innovative and creative Mechanical Engineers catering the global industrial requirements and social needs”

MISSION	
M1:	To prepare effective and responsible graduate engineers for global requirements by providing quality education.
M2:	To enhance knowledge through project and internship in the field of mechanical and allied engineering.
M3:	To guide students in acquiring career oriented jobs in the field of mechanical engineering.
M4:	To provide academic environment of excellence, leadership, ethical values and lifelong learning to cater the need of society by sustainable solutions.

Fluid Mechanics & Hydraulic Machines Lab (120314/190314)

Course Outcomes

After successful completion of this course students will be able to:

CO1: Experiment with flow measurement devices like venturimeter and orifice meter

CO2: Estimate the friction and measure the frictional losses in fluid flow

CO3: Predict the coefficient of discharge for flow through pipes

CO4: Evaluate pressure drop in pipe flow using Hagen-Poiseuille's equation for laminar flow in a pipe

CO5: Calculate the Critical Reynolds's Number through Pipe Set Apparatus

CO6: Explain the working principles of Fluid machines and apply it to various types of machines

Holistic Assessment Rubric for Practical

Criteria	Poor 0 pts Marks: <15	Fair 1 pts Marks: 15-20	Good 2 pts Marks: 20-25	Excellent 3 pts Marks: 25-28	Outstanding 4 pts Marks: 28-30
Follow directions/instructions	● Disinterested	● Shows little interest	● appears interested	● makes sure that every instruction is followed	● followed each instruction with utmost care
Following Procedure / Procedural knowledge	● Lacks the appropriate knowledge of the lab procedures. ● Has no idea what to do. ● Often requires help from the teacher to complete basic procedures.	● Demonstrates general knowledge of lab procedures. ● Has some idea of what to do. ● Asks questions to teacher that is answered in the procedure, more than once.	● Demonstrates good knowledge of the lab procedures. ● Will ask peers for help with problems in lab procedures, before asking the teacher. ● Works to follow each step before moving on to the next step.	● Demonstrates sound knowledge of lab procedures. ● Will discuss with peers to solve problems in procedures. ● Carefully follows each step and checks them off as they are completed.	● Demonstrates superb knowledge of the lab procedures. ● Willingly helps other students to follow and understand procedures. ● Thoroughly and carefully follows and checks off each step before moving on to next step and encourages other group members to do the same.
Lab Techniques / use of equipment/ instruments/ software/analytical skill	● Measurements, skills or techniques are incomplete, inaccurate and/or imprecise.	● Measurements, skills or techniques are somewhat inaccurate and very imprecise.	● Measurements, skills or techniques are mostly accurate.	● Measurements, skills or techniques are accurate with reasonable precision.	● Measurements, skills or techniques are both accurate and precise and may show innovation.
Criteria	**Poor 0 pts Marks: <15**	**Fair 1 pts Marks: 15-20**	**Good 2 pts Marks: 20-25**	**Excellent 3 pts Marks: 25-28**	**Outstanding 4 pts Marks: 28-30**
Safety/ethical aspects	● Proper safety precautions are consistently missed; using equipment not for intended purpose.	● Proper safety precautions are often missed, as listed at left;	● Proper safety precautions are generally used,	● Proper safety precautions are consistently used.	● Proper safety precautions are consistently used. Thinks ahead to ensure safety and reminds other group members to do the same.
Clean-up	● Proper clean-up procedures are seldom used. ● All items left at station or station not cleaned.	● Needs to be reminded more than once during the lab to use proper clean-up procedures. ● Few items left at station or not cleaned.	● Proper clean-up procedures generally used. ● Station generally left clean.	● Consistently uses proper clean-up procedures. ● Reminds others of their responsibility; Station generally neat and clean.	● Consistently uses proper clean-up procedures. ● Station left neat and clean, pitches in and helps others clean up and directs others to do the same.
Troubleshooting	● Not able to identify problem	● Identifies problem, but does not know solution	● Identifies problem but not sure of solution	● Identifies problem and able to rectify with minor errors	● Identifies problem and rectify completely
Documentation of lab work	● Poor documentation ● Observations are incomplete or not included.	● Documented but not presented up to mark ● Observations are incomplete	● Documented ● Observations are generally complete. ● Work is organized. ● Only 2-3 minor error	● Documented ● Observations are thorough. ● Work is generally neat and organized.	● Documented ● Observations are very thorough and may recognize possible errors in data collection.

Safety and Security rules to be followed in Fluid Mechanics and Machinery Lab

1. Always wear shoes before entering lab.

2. Do not touch anything without the permission of Instructor/lab assistant.

3. Read carefully the lab manual before performing experiments.

4. Check electrical connections before starting the equipment.

5. Do not put your hands while the machine is in operation.

6. Do not tamper measuring instruments.

7. Do not open the casing of the equipment.

8. Do not unplug any electrical connection.

9. Switch off the power supply to the experimental setup on completion of the experiment.

10. Maintain clean and orderly laboratories and work area.

11. Be aware of the various experiment controls (start button, stop button, speed control) for each equipment.

12. Wear safety eyewear when needed.

13 Do not leave experiments running unattended.

14 Any injuries should be reported immediately for proper care.

(Prof. I/c Lab.)

List of Experiments

1. To find out coefficient of discharge of a given venturimeter.

2. To determine the hydraulic coefficient C_v , C_c , and C_d for (i) Orifice and (ii) Mouth Piece

3. To study the flow over a Rectangular notch to find the coefficient of discharge for it .

4. To determine the coefficient of friction for pipes of different sizes.

5. To verify the Bernoulli's theorem experimentally i.e. conservation of mechanical energy

6. Study of Redwood viscometer.

7. To study of different types of flow (Reynold's experiment)

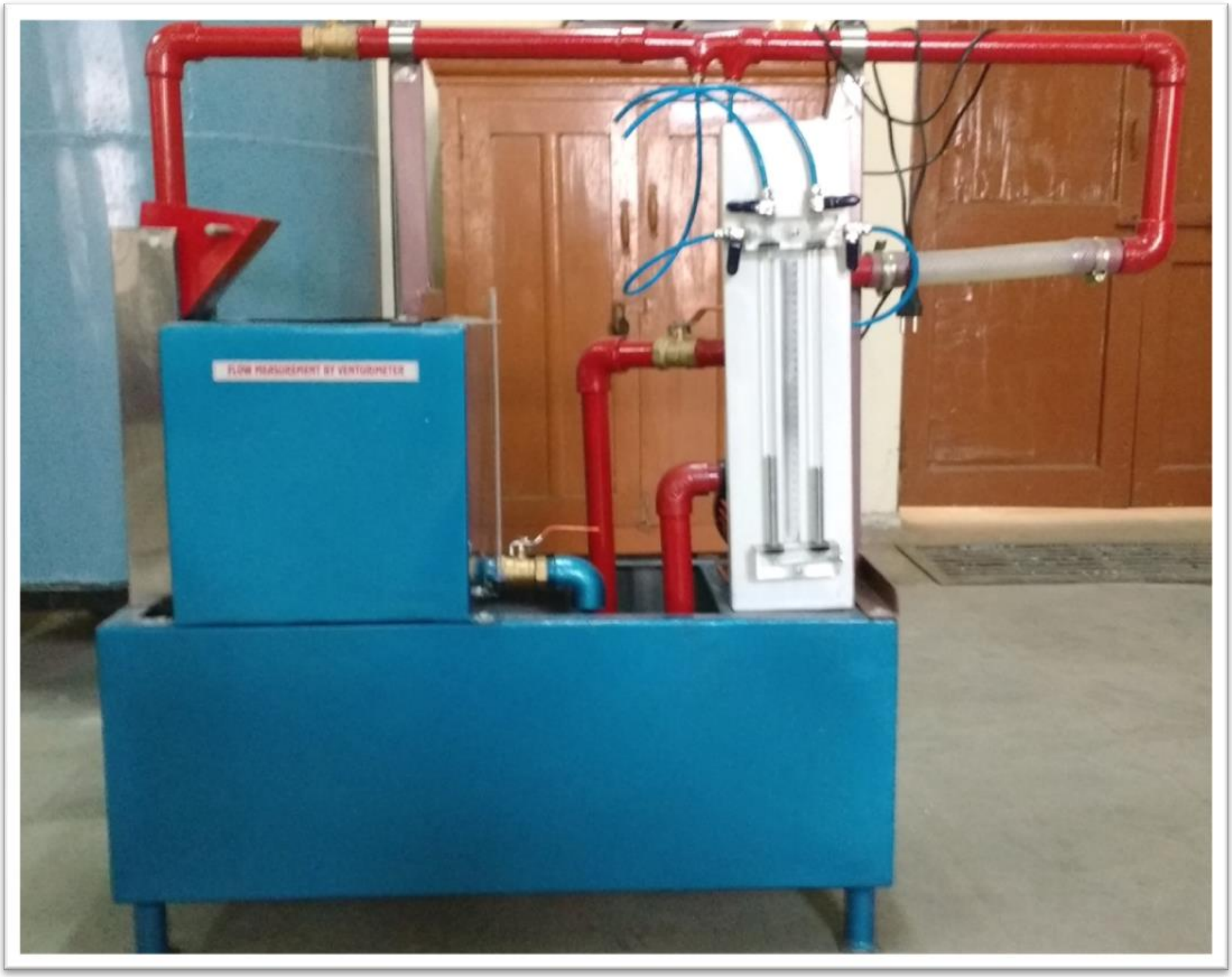
8. Experimental determination of metacentric height of a ship model .

9. To conduct load test on Pelton Wheel Turbine and to study the characteristics of pelton wheel turbine

10. To study the performance characteristics of a centrifugal pump and to determine the characteristic with maximum efficiency.

EXPERIMENT NO.1

Venturimeter

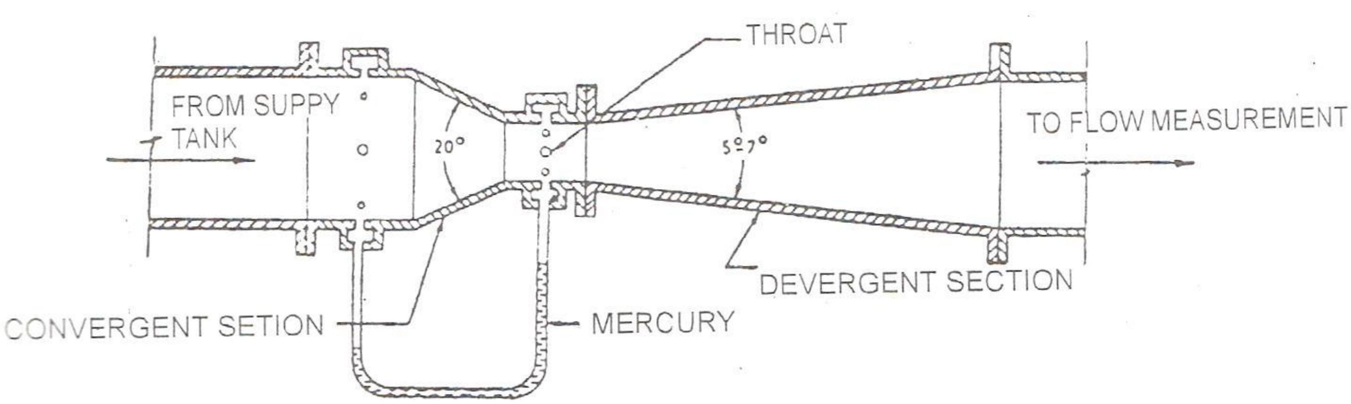


Objective:

To determine the coefficient of discharge for a horizontal venturimeter.

Equipment Required:

Water main with a supply valve, sump tank, a venturimeter, mercury differential U tube manometer, discharge measuring tank fitted with a



piezometer tube, a stop watch.

THEORY:

Venturimeter: It is a device for measuring rate of flow in a pipeline. Its theoretical analysis is based on

(i) Bernoulli's equation
(ii) Continuity equation.

Construction features: It is composed of the following three features:

1. A converging entrance cone of angle of about 20°

2. Throat – a cylindrical portion of short length and

3. Diffuser – a diverging cone of angle 5 ° to 7 °

The accelerated flow is achieved in the converging cone, the highest velocity head being at the throat. In the converging cone pressure energy is converted into kinetic energy. At the throat the streamlines are parallel to each other and

C_c = 1. Whereas in the converging cone the kinetic energy is converted into pressure energy and thus to reduce the velocity and the pressure as nearly as possible to its original value at the inlet. About 85% of the pressure drop between the inlet and throat is covered in the diffuser. The fluid flowing through diverging boundaries has a tendency to separate from boundaries thereby resulting in energy dissipation due to formation of eddies etc. Energy dissipation has been found to be directly proportional to the angle of divergence; however, small angles of divergence require large lengths of diffusers. Cone angles of 5^o to 7^o have been found to give good results viz., lower values of energy loss.

For a venturimeter to give good results the flow entering it should be free from large scale turbulence. The factors to be borne in mind are:

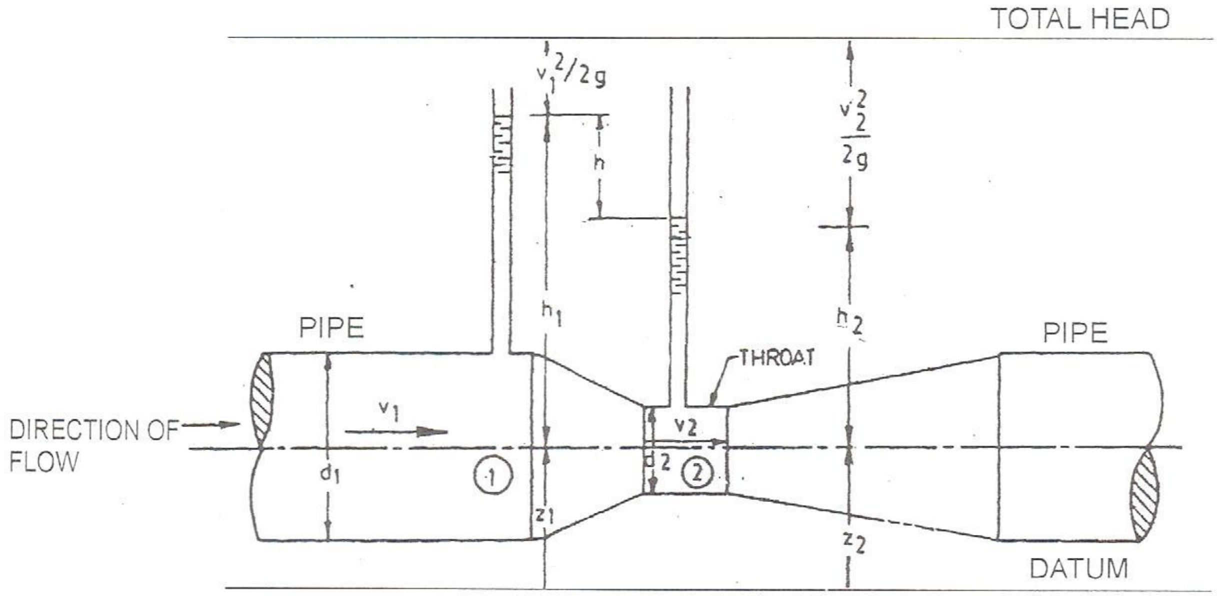
A venturimeter ought to be proceeded by a straight length of around 50 times pipe diameter but not less than 30 times the pipe diameter.

The ratio of throat to inlet diameters may range between 0.75 and 0.25 but most commonly used rates adopted is 0.5.

Experimental Setup:

The experimental setup consists of:

1. Water main connected to the U/s end of the venturimeter.
2. Horizontal venturimeter with a mercury differential U tube manometer connected between two pet-cocks at the mouth and throat by means of flexible tubes.
3. Mercury U-tube manometer with an air vent with the help of which the water levels in the limbs may be brought to the desired part of the scale regardless of the pressure in the mains.
4. Outlet value is fitted at the d/s end of venturimeter for discharging regulation.
5. Discharge measuring tank fitted with a piezometer tube.



Procedure:

1. Open the air vessel valve & release the air on manomatric tube and weight the leveling of mercury. After leveling the mercury, close the air vessel valve.
2. Switch on the power & start the motor.
3. Open the regulation valve and under steady state condition note the readings h_1 and h_2 in the two limbs of the mercury differential manometer.
4. Note the initial level of water in measuring tank. Collect the water in the measuring tank for certain time and note the final level of water in measuring tank. Calculate the actual discharge.
5. Calculate the theoretical discharge Q_{th} and $C_d = \frac{Q_{act}}{Q_{th}}$
6. Vary the flow rate through the system with the regulating valve and take different readings.

Specification:

A	=	Area of Measuring tank cm^2
h_1	=	height of Measuring Tank initial reading level
h_2	=	height of measuring tank final level reading t Second
h	=	$(h_2 - h_1)$

$$H = R\left(\frac{\rho_m}{\rho_f} - 1\right)$$

Where, R = Mercury Difference

ρ_m = Density of Mercury

ρ_f = Density of fluid

H = Difference in Manometer in the Cm of water.

a_1 = Area of pipe cm^2

a_2 = Area of throat cm^2

Density of Manometer fluid mercury (pm) = 13.6 kg/cm^3

Density of water (ρ_f) = 1 kg/ cm^3

Diameter of pipe d_1 = 2.5 cm

Diameter of throat d_2 = 1.5 cm

Area of pipe $a_1 = \frac{\pi}{4} d_1^2$ = 4.90 cm^2

Area of throat $a_2 = \frac{\pi}{4} d_2^2$ = 1.77 cm^2

g = 981 cm/sec^2

FORMULA USED :

$$C_d = \frac{Q_{act}}{Q_{th}}$$

$$Q_{act} = \frac{(h_2 - h_1)A}{t}$$

$$Q_{th} = \frac{\sqrt{2gH}(a_1 \times a_2)}{\sqrt{a_1^2 - a_2^2}}$$

"ORIFICEMETER" Example Reading 1st Calculation

Area of measuring tank (A)	= 30 cm x 30 cm = 900 cm^2
Diameter of pipe d_1	= 2.5 cm
Diameter of throat d_2	= 1.5 cm
Area of pipe $a_1 = \frac{\pi}{4} d_1^2$	= 4.90 cm^2
Area of throat $a_2 = \frac{\pi}{4} d_2^2$	= 1.77 cm^2
g	= 981

FORMULA USED:

$$Q_{act} = \frac{A(h_2 - h_1)}{t} = \frac{900 \times (21.2 - 5)}{30} = 486$$

$$Q_{th} = \frac{\sqrt{2gH}\,(a_1 \times a_2)}{\sqrt{a_1^2 - a_2^2}} = \frac{\sqrt{2 \times 981 \times (16.6 - 13.3) \times 12.6} \times (4.90 \times 1.77)}{\sqrt{(4.9)^2 - (1.77)^2}} = 533.79$$

$$C_d = \frac{Q_{act}}{Q_{th}} = \frac{486}{533.79} = 0.91$$

S. NO.	MEASUREMENT TANK READING				Discharge actual $Q_{act} = \frac{A(h_2 - h_1)}{t} cm^3/\sec$
	Initial level Cm h_1	Final level Cm h_2	h_2 - h_1	Time t sec	
Exampl e Reading 1	5	22.4	15.4	30	462
1					
2					
3					

S. NO.	Manometer Difference R cm of Hg			$H = R(\frac{\rho_m}{\rho_f} - 1)$ $H = R(\frac{13.6}{1} - 1)$ $H = R \times 12.6cm$ of H_2O	Discharge theoretical $Q_{th} = \frac{\sqrt{2gH}(a_1 \times a_2)}{\sqrt{a_1^2 - a_2^2}}$	$C_d = \frac{Q_{act}}{Q_{th}}$
	h_1	h_2	R = h_2 - h_1			
Example Reading 1	10	13.1	3.1	39.06	539.82	0.86
1						
2						
3						

Video link for the experiment

https://youtu.be/3wfUev6TQv0

https://youtu.be/iDaK0voByiI

VENTURIMETER SAMPLE READINGS

S. NO.	MEASUREMENT TANK READING				Discharge actual $Q_{act} = \frac{A(h_2 - h_1)}{t} cm^3 / \sec$
	Initial level Cm h_1	Final level Cm h_2	h_2 - h_1	Time t sec	

1	5	22.4	15.4	30	
2	2.9	12.9	10	32.0	
3	4.8	14.8	10	19.0	
4	3.9	13.9	10	15.6	

S. NO.	Manometer Difference R cm of Hg			$H = R(\frac{\rho_m}{\rho_f} - 1)$ $H = R(\frac{13.6}{1} - 1)$ $H = R \times 12.6 cm$ of H_2O	Discharge theoretical $Q_{th} = \frac{\sqrt{2gH}(a_1 \times a_2)}{\sqrt{a_1^2 - a_2^2}}$	$C_d = \frac{Q_{act}}{Q_{th}}$
	h_1	h_2	R = h_2 - h_1			
1	10	13.1				
2	2.9	3.0				
3	4.8	5.1				
4	3.9	5.9				

Diameter of pipe d_1 = 2.5 cm

Diameter of throat d_2 = 1.5 cm

EXPERIMENT NO. 2

ORIFICE AND MOUTH PIECE.

Objective:

To determine the hydraulic coefficients C_v, C_c and C_d for:

(i) Orifice
(ii) Mouth Piece

Equipment Required:

(i) Supply tank fitted with round orifice, Mouth piece scale and sliding arrangement: water inlet pipe and Piezometer tube.
(ii) Measuring tank.
(iii) Stand for mounting supply tank.

Theory:

Orifices are devices used for discharging fluids into the atmosphere. It is the opening in the wall of a tank or in a plate which may be fitted in a pipe such that the plate is normal to the axis of the pipe. The discharging fluid from the tank/conduit through the orifice comes out in the form of a free jet. In the process, the total energy of the fluid in the tank is converted to kinetic energy as the jet issues out into the atmosphere. The jet cross section initially contracts to a minima and then expands partly due to the viscous resistance offered by the surrounding atmosphere and partly due to inertia of the fluid particles. The section which has the minimum area is known as 'vena contracts'. The contraction and expansion of the jet results in loss of energy.

The actual velocity at vena contracts is smaller than the theoretical velocity due to frictional resistances at the orifice edges. The ratio between the actual velocity and the theoretical velocity of the jet is known as coefficient of velocity C_v. Its value also depends upon the size and shape of the orifice and the head causing flow. The coefficient velocity for a vertical orifice is determined experimentally by measuring the horizontal and vertical coordinates of the issuing jet. The water flows through an orifice under a constant head H. Let V be the actual velocity (which is horizontal) of the jet. Obviously, while covering horizontal distance, the jet is acted upon by gravity with a downward acceleration 'g'. Consider a small particle of water at vena contracts. Suppose it falls through a vertical distance 'y' in a horizontal distance x, in time t sec.

Then x = Vt and y = $\frac{1}{2}gt^2$

Or $$y = \frac{1}{2}\frac{gx^2}{V^2}$$

Or $$V = \sqrt{\frac{gx^2}{2y}}$$

But theoretical velocity $V = \sqrt{2gH}$

$$C_v = \sqrt{\frac{gx^2}{2y \times 2gH}} = \sqrt{\frac{x^2}{4yH}}$$

Since actual area of the jet is less than the area of the orifice, and the actual velocity is less than the theoretical velocity; therefore, actual discharge is less than the theoretical discharge. The ratio between the actual discharge and the theoretical discharge is called coefficient of discharge C_d.

$$\therefore \quad C_d = \frac{Q_{act}}{a\sqrt{2gH}}$$

where $a\sqrt{2gH}$ is the theoretical discharge

The actual discharge passing through an orifice = Actual velocity at vena contracts

X Area of jet at vena contracts

$$= C_v \sqrt{2gH} \times C_c \times a$$

But $a\sqrt{2gH}$ = Theoretical discharge through orifice.

i.e. $$\frac{Actual \quad discharge \quad through \quad orifice}{Theorical \quad discharge \quad through \quad orifice} = \frac{C_v\sqrt{2gH}}{a\sqrt{2gH}} \times C_c \times a \; = C_v \times C_c$$

i.e. $C_d = C_v \times C_c$

$$C_c = \frac{C_d}{C_v}$$

Procedure:

1. Adjust the inflow of water to the inlet tank till the steady state condition is achieved by in and outflow from the orifice and the head causing flow through the orifice as indicated by the Piezometer tube is constant. Measure the head 'H'.

2. Using the hook gauge, measure x and y coordinates at different points on the centre line of the jet. Knowing 'h'; the head causing flow and x and y co-ordinates, coefficient of velocity can be obtained from the formula.

$$C_v = \sqrt{\frac{x^2}{4yH}}$$

3. Note the initial reading of water level in the measuring tank, and simultaneously start the stop watch. After an interval of time note the reading of the water level. Difference in the two readings gives the rise in water level during the given time. Knowing, area of measuring tank, actual discharge Q_a can be obtained. Hence C_d can be calculated as

$$C_d = \frac{Q_{act}}{a\sqrt{2gH}}$$

Calculate $C_c = \frac{C_d}{C_v}$

4. Repeat the above steps for different heads h and take five readings.

5. Repeat the experiment for mouth piece and convergent orifice.

Observation:

Dia. of circular orifice = 1 cm

Area of circular orifice (a) $= \frac{\pi D^2}{4}$ cm² $= \frac{3.14 \times 1^2}{4}$

= 0.78 cm²

Dia. of circular mouth piece = 1 cm

Area of circular mouth piece (a) $= \frac{\pi D^2}{4}$ cm^2 $= \frac{3.14 \times 1^2}{4}$

= 0.78 cm^2

Sump Tank = 30 X 30 X 80 cm

Area of collecting tank (A) = 30cm x 30cm = 900 cm^2

S. NO.	MEASUREMENT TANK READING				Discharge $Q_{act} = \frac{A(h_2 - h_1)}{t} cm^3/\sec$	Head H cm
	Initial level Cm h_1	Final level Cm h_2	h_2 - h_1	Time t sec		
Example 1	5	9.8	4.8	30	144	52
Example 2	5	10.6	5.5	30	165	46
1						
2						
3						

OBSERVATION TABLE FOR Cv, Cc and Cd FOR MOUTHPIECE

S. NO.	X AXIS (in cm)			Y AXIS (in cm)			$Q_{th} = a\sqrt{2gH}$	$C_d = \frac{Q_{act}}{a\sqrt{2gH}}$	$C_v = \sqrt{\frac{x^2}{4yH}}$	$C_c = \frac{C_d}{C_v}$
	X_1	X_2	$X = X_2 - X_1$	Y_1	Y_2	$Y = Y_2 - Y_1$				
Example 1	0	26	26	0	10	10	249.14	0.58	0.57	1.02
Example 2	0	24	24	0	8	8	300.42	0.54	0.62	0.88
1										
2										
3										

OBSERVATION TABLE FOR Cv, Cc and Cd FOR ORIFICE

S. NO.	MEASUREMENT TANK READING				Discharge $Q_{act} = \frac{A(h_2 - h_1)}{t} cm^3/\sec$	Head H cm
	Initial level Cm h_1	Final level Cm h_2	$h_2 - h_1$	Time t sec		
Example 1	5	10.2	5.2	30	156	55

Example 2	5	10.5	5.5	30	165	48
1						
2						
3						

S. NO.	X AXIS (in cm)			Y AXIS (in cm)			$Q_{th} = a\sqrt{2gH}$	$C_d = \frac{Q_{act}}{a\sqrt{2gH}}$	$C_v = \sqrt{\frac{x^2}{4yH}}$	$C_c = \frac{C_d}{C_v}$
	X_1	X_2	$X = X_2 - X_1$	Y_1	Y_2	$Y = Y_2 - Y_1$				
Example 1	0	23	23	0	8	8	256.23	0.61	0.54	1.13
Example 2	0	26	26	0	10	10	229.18	0.72	0.59	1.22
1										
2										
3										

Video link for the experiment:

https://youtu.be/xq_IgKAPt_c

SAMPLE READINGS FOR Cv, Cc and Cd OF ORIFICEMETER

S. NO.	MEASUREMENT TANK READING				Discharge $Q_{act} = \frac{A(h_2 - h_1)}{t} cm^3/\sec$	Head H cm
	Initial level Cm h_1	Final level Cm h_2	h_2 - h_1	Time t sec		
Example 1	5	10.2	5.2	30		55
Example 2	5	10.5	5.5	30		48
1	4.9	9.9	5.0	61		21
2	5.6	10.6	5.0	56		26
3	3.9	8.9	5.0	49		30

S. NO.	X AXIS (in cm)			Y AXIS (in cm)			$Q_{th} = a\sqrt{2gH}$	$C_d = \frac{Q_{act}}{a\sqrt{2gH}}$	$C_v = \sqrt{\frac{x^2}{4yH}}$	$C_c = \frac{C_d}{C_v}$
	X_1	X_2	X = X_2 - X_1	Y_1	Y_2	Y = Y_2 - Y_1				
Example 1	0	23	23	0	8	8	256.23	0.61	0.54	1.13
Example 2	0	26	26	0	10	10	229.18	0.72	0.59	1.22
1	0	15.73	15.73	0	8.81	8.81				
2	0	22.28	22.28	0	11.12	11.12				
3	0	21.6	21.61	0	7.58	7.58				

EXPERIMENT NO.3

NOTCHES OR WEIR

Objective:

To study the flow over a Rectangular notch & to find the coefficient of discharge for it along with to calibrate it for discharge measurement in a free surface flow.

Theory:

A weir is an obstruction placed across a free-surface flow such that the flow takes place over it. Notches are openings cut in metallic plates and installed in flumes or small channels. Installation of a notch is exclusively for the purpose of measuring the discharge in the steam.

A sharp crested weir or notch for the measurement of discharge generally have a regular geometrical shape like triangular. The free surface flow taking place over it acquires steady state conditions such that the discharge is uniquely related to the head *H* over the crest of the notch-measured at a distance about 3 to 4 times *H* from the crest towards upstream

The discharge over a triangular or V-Notch is given by the formula

$$Q = \frac{8}{15} C_d \sqrt{2g} \times \tan \theta/2 \times H^{5/2}$$

Where θ is the angle of triangular notch.

discharge of a rectangular notch is given by

$$Q_{Itheoretical} = 2/3\ B \sqrt{2g}\ H^{3/2}$$

The value of C_d is given by the ratio of Q_{actual} / $Q_{Itheoretical}$

In actual practice, the discharge over a notch is considerably less than indicated by the above formula without considering C_d i.e., the formula is derived on the basis of frictionless one dimensional flow. The discrepancy arises due to real flow effects like viscosity, end contractions, nappe suppression, ventilation of weirs etc. So the actual discharge is obtained by multiplying the theoretical discharge by C_d, as given in the above formula.

Experimental Setup:

Refer figure. The set up consists of:

1. A tank on the raised platform.
2. A water inlet pipe with a regulating valve.
3. Vertical perforated plates (Baffle plates) are fitted in the tank having the notch to decrease the tubulence and thereby velocity of approach.
4. A hook gauge with a vernier scale.
5. A discharge measuring tank fitted with a piezometer tube and a graduated scale to measure the flow through/over the notch.

Procedure:

1. Record the geometrical features of the notch.
2. Allow the water into the tank till it just starts passing over the notch.
3. Stop the supply of water and record the level of water by hook gauge when no water passes over the notch. This gives level of still of the crest (h_1).
4. Increase the supply of water till the head over the still of the notch becomes constant. Record the level (H_2) of free liquid surface. Difference of the two readings (H_2-H_1) gives the head over the still causing flow.
5. Measure the flow rate (Q) with the help of discharge measuring tank and stop watch.
6. Vary the flow rate through the system with a regulating valve and take eight different readings.
7. Repeat the experiment for different type of Notches.

Observation:

Sump Tank = 30 X 30 X 80 cm

Area of Measuring Tank A = 30 x 30 cm = 900 cm^2

Angle of V - Notch = 45^o

Area of Rectangular Notch = 10 x 10 cm = 100 cm^2

FORMULA USED

For V - Notch

$$Q_{act} = \frac{A(h_2 - h_1)}{t} cm^3 / \sec$$

$$Q_{th} = \frac{8}{15}\sqrt{2g}\tan\theta/_2 H^{5/2}$$

Where H = Head over the Notch

θ Is the angle of V Notch

Let $K = \frac{8}{15}\sqrt{2g}\tan\theta/_2$

$$Q_{th} = KH^{5/2}$$

$$C_d = \frac{Q_{act}}{Q_{th}}$$

For Rectangular Notch

$$Q_{act} = \frac{A(h_2 - h_1)}{t} cm^3 / \sec$$

$Q_{Itheoretical}$ = 2/3 B √2g H$^{3/2}$

Where B = Width of rectangular Notch,

H = Head over the Notch

$$C_d = \frac{Q_{act}}{Q_{th}}$$

OBSERVATION TABLE FOR V-NOTCH

S. NO.	MEASUREMENT TANK READING				Discharge actual $Q_{act} = \frac{A(h_2 - h_1)}{t} cm^3 / \sec$
	Initial level Cm h_1	Final level Cm h_2	h_2 - h_1	Time t sec	
Example 1	5	20.6	15.6	30	468
Example 2	5	32.8	27.8	30	834
1					
2					
3					

S. NO.	Pointer Gauge Reading	V-NOTCH	$C_d = \frac{Q_{act}}{Q_{th}}$

	h_1	h_2	$H = h_2 - h_1$	$Q_{th} = \frac{8}{15}\sqrt{2g}\tan\frac{\theta}{2} H^{5/2}$	
Example 1	4	9.2	5.2	567.89	0.82
Example 2	4	10.5	6.5	1030.67	0.81
1					
2					
3					

OBSERVATION TABLE FOR RECTANGULAR-NOTCH

S. NO.	MEASUREMENT TANK READING				Discharge actual $Q_{act} = \frac{A(h_2 - h_1)}{t} cm^3/\sec$
	Initial level Cm h_1	Final level Cm h_2	$h_2 - h_1$	Time t sec	
Example 1	5	21.2	16.2	30	486
Example 2	5	30.8	25.8	30	774
1					
2					
3					

S. NO.	Pointer Gauge Reading			RECTANGULAR-NOTCH $Q_{th} = \frac{8}{15}\sqrt{2g}BH^{3/2}$	$C_d = \frac{Q_{act}}{Q_{th}}$
	h_1	h_2	H = $h_2 - h_1$		
Example 1	4	6.1	2.1	611.07	0.79
Example 2	4	7.2	3.2	1149.45	0.67
1					
2					
3					

Results: -

Conclusion:-

Precautions:-

1. Do not close air regulating valve fully to avoid over loading at blower meter.
2. Use only mild detergents to clean the instruments do never use any organic solvent and strong acid or alkali.
3. Ground the instrument properly to avoid electric shock.
4. The density of fluid in manometer is one.

Video Links for experiments:

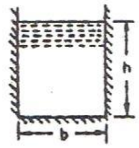
https://youtu.be/_kcqXDfk1a8

https://youtu.be/tMXnSyLC0M8

SAMPLE READINGS FOR RECTANGULAR NOTCH EXPERIMENT

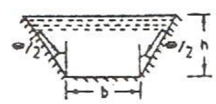
S. NO.	MEASUREMENT TANK READING (Cross section 30x30 cm)				Actual discharge
	Initial level Cm h_1	Final level Cm h_2	$h_2 - h_1$ cm	Time t sec	
1	3.2	13.2	10.00	41	
2	3.7	13.7	10.00	21	
3	4.2	14.2	10.00	15	

S. NO.	Pointer Gauge Reading (cm)			Q	$C_d = \frac{Q_{act}}{Q_{th}}$
	h_1	h_2	$H = h_2 - h_1$		
1	15.14	16.23			
2	15.14	16.93			
3	15.14	17.24			

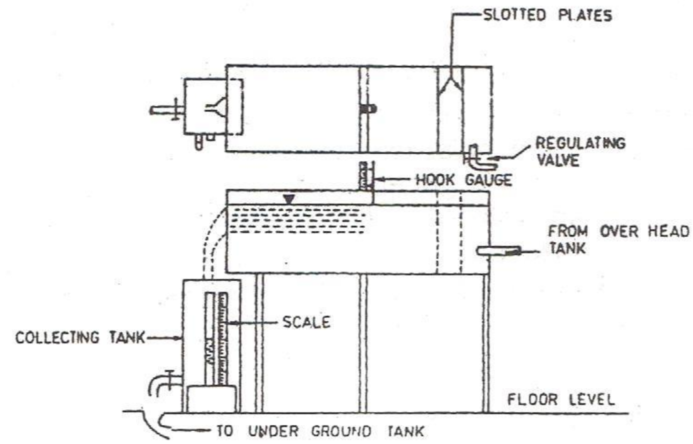


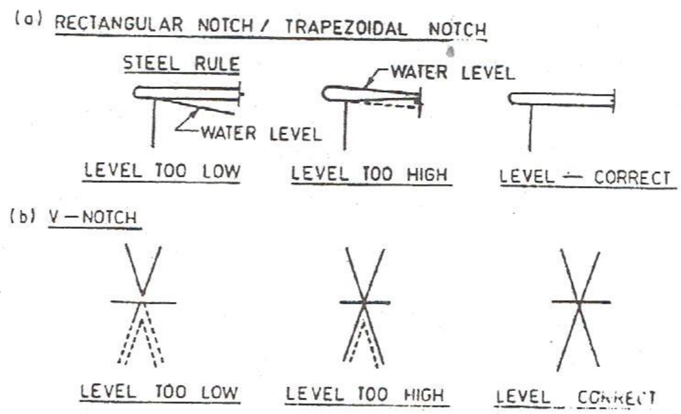
(a) RECTANGULAR NOTCH

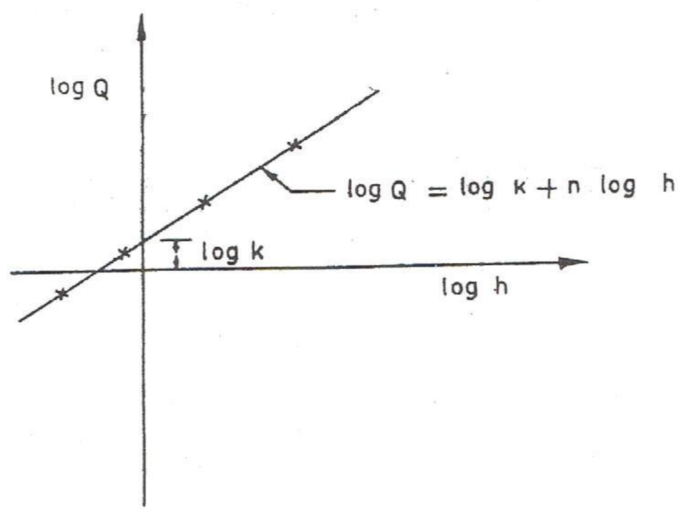
(a) TRIANGULAR NOTCH



(C) TRAPEZOIDAL NOTCH







EXPERIMENT NO.4
BERNOULLI'S THEOREM APPARATUS

Objective: - To verify the Bernoulli's theorem experimentally i.e. conservation of mechanical energy

Theory: - Bernoulli's equation states as follows:

"In an ideal, incompressible fluid flow when the flow is steady and continuous, the sum of pressure energy, kinetic energy and potential energy is constant along a stream line".

Mathematically,

$$\frac{p}{w} + \frac{V^2}{2g} + z = Constant$$

For two sections

$$\frac{p_1}{w} + \frac{V_1^2}{2g} + z_1 = \frac{p_2}{w} + \frac{V_2^2}{2g} + z_2$$

This is called Bernoulli's equation.

Assumptions: It may be mentioned that the following assumptions are made in the derivation of Bernoulli's equation.

1. The liquid is ideal and incompressible.
2. The flow is steady and continuous.
3. The flow is along the streamline, i.e. it is one-dimensional.
4. The velocity is uniform over the section and is equal to the mean velocity.
5. The only forces acting on the fluid are the gravity forces and the pressure forces.

Rate of flow or Actual Discharge (*Q*):

The water flowing through the section of a pipe or a channel under the steady state conditions is collected in a collecting tank for a known time *t*. The rise of water level in the collecting tank is noted down. The actual discharge is

$$Q = \frac{area\ of\ the\ collecting\ Tank\ \ x\ \ rise\ of\ water\ level\ in\ the\ collecting\ Tank}{time(t)}$$

Description:-

The experimental set up consists of a horizontal Perspex duct of smooth variable cross-section of convergent and divergent type. The section is 40 mm x 40 mm at the entrance and exit and 40 mm x 20 mm at middle. The total length of duct is 90 cm. The piezometric pressure P at the locations of pressure tapping is measured by means of 11 piezometer tubes installed at an equal distance 7.5 cm along the length of conduit. The duct is connected with supply tanks at its entrance and exit end with means of varying the flow rate. A collecting tank is used to find the actual discharge.

Data: area of collecting tank, A= 0.1 m^2

Procedure:

1. Clean the apparatus and make all tanks free from dust
2. Close the drain valve provided.
3. Fill sump tank ¾ with clean water and ensure that no foreign particles are there.
4. Close all control valves given on the water line and open by-pass valve.
5. Ensure that ON/Off switch given on the panel is at OFF position.
6. Now switch on the main power supply.
7. Switch ON the pump.
8. Operate the flow control valve to regulate the flow of water.
9. Measure the height of water level in tubes.
10. Measure the flow rate using measuring tank and stop watch

11. Repeat steps the same procedure for different flow rates of water operating control valves and By-pass valve.
12. When experiment over switch OFF pump.
13. Switch off power supply to panel.

Observation Table:-

S. No	Discharge Measurement		Discharge Q, cm^3/sec	Diameter of passage mm.	Area of c/s of passage A, cm^2	$V^2/2g$ cm	$P/w + Z$ cm	$P/w + Z + V^2/2g$ cm
	Rise of water level (h_2-h_1)	Time sec						

Calculation:-

1. Compute the area of cross section 'a' at a given section
   $a = \pi d^2/4$
2. Calculate Discharge: $Q = A\frac{(h_2-h_1)}{t}$
3. Velocity of flow: V=Q/a
4. Velocity head= $V^2/2g$

Results: -

Conclusion:-

Precautions:-

1. Apparatus should be in leveled conditions.
2. Reading must be taken in steady or nearby steady conditions and it should be noted that water level in the inlet supply tank should reach the overflow condition.
3. There should not be any air bubble in the piezometer and in the Perspex duct.
4. By closing the regulating valve, open the control valve slightly such that the water level in the inlet supply tank reaches the overflow conditions. At this stage check that pressure head in each piezometer tube is equal. If not adjust the piezometers to bring it equals.

EXPERIMENT NO.5
PIPE FRICTION

Objective:

To determine the coefficient of friction for pipes of different sizes.

1. 1.5 cm

2. 2.5 cm

Theory:

Transportation of fluids through pipes is frequently dealt with by engineers. Distribution of water and gas for domestic consumption through pipes is an example. Experimental observations by Froude on long, straight and uniform diameter pipes on the flow of water indicated that head loss due to friction h_f between two sections of the pipes varied in direct portion with the velocity head $V^2/2g$, the distance between the two sections, L and inversely with the pipe diameter, d. By introducing a coefficient of proportionality 'f' called the friction factor Darcy and Weisbach proposed the following equation for head loss due to friction a pipe.

$$h_f = f\frac{L}{d} \times \frac{V^2}{2g}$$

Experimental Setup:

1. The experimental set up consists of:
2. Pipes of different diameters. Two pipe of dia 1.5cm, 2.5cm
3. Two pet-cocks on each side with the help of which flow is regulated.
4. A valve fitted to each pipe with the help of which flow is regulated
5. An U tube manometer connected to the pressure tapping of each pipe.

6. A discharge measuring tank fitted with a piezometer tube and a graduated scale to measure the depth of water collected.

Procedure:

1. Open the air vessel valve & release the air on manomatric tube and weight the leveling of mercury. After leveling the mercury, close the air vessel valve.

2. Switch on the Power & Start the Motor

3. Record the diameter‘d’ of the pipe and the length L between the sections attached to the limbs of U-tube manometer.

4. Open the supply valve to allow water to flow in one pipe only.

5. Record the initial water level (y_1) in the piezometer fitted to the discharge measuring tank and start the stop watch and find the depth of water collected for a particular time by recording the final reading (y_2) of the piezometer.

6. Knowing the area of the measuring tank, flow discharge through the pipe can be obtained.

7. Record the readings of the two limbs of the inverted U tube manometer, the difference of which gives the head loss h_f,

8. Calculate average velocity through the pipe using the relationship
$$V = \frac{Q}{a}$$

   Where a = area of cross section of the pipe.

9. The darcy Weisbach coefficient of friction is calculated using the expression

$$F = \frac{2gdh_f}{LV^2}$$

10. Repeat the above steps for different discharge and other pipes of different diameters taking at least 3 readings for every pipe.

Observation:

Density of Manometer fluid ρ_m = 13.6 kg/cm^3

Density of Water ρ_f = 1.0 kg/cm^3

Sump Tank = 30 X 30 X 80 cm

Area of Tank A = 30cm x 30cm

= 900 cm^2

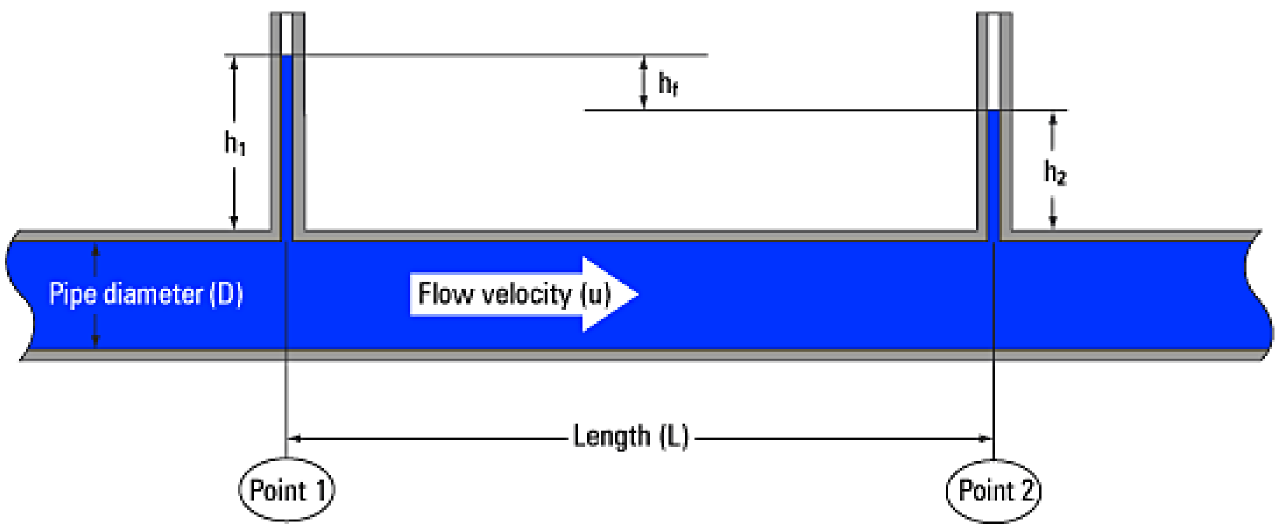
Distance between pressure tapping attached to Limbs of manometer in each pipe L = 100 cm

Pipe (1) Dia of pipe (d) (3/4 inch) = 1.50cm

Area of pipe (a) = $\frac{\pi}{4}d^2$ = 1.77 cm^2

Pipe (2) Dia of pipe (d) (1 inch) = 2.5 cm

Area of pipe (a) = $\frac{\pi}{4}d^2$ = 4.91 cm^2



Observation Table:

S. NO.	MEASUREMENT TANK READING				Discharge actual $Q_{act} = \frac{A(h_2 - h_1)}{t} cm^3/\sec$
	Initial level Cm h1	Final level Cm h2	h2 - h1	Time t sec	
EX. Reading 2.5 Cm	2	11.6	9.6	15	576
1					
2					
3					

S. NO.	Manometer Difference R cm of Hg			$h_f = R(\frac{\rho_m}{\rho_f} - 1)$ $h_f = R(\frac{13.6}{1} - 1)$ $h_f = R \times 12.6cm$ of H_2O	Velocity of water $V = \frac{Q}{a}$	$F = \frac{2gdh_f}{LV^2}$
	h_1	h_2	R = $h_2 - h_1$			
EX. Reading 2.5 Cm	4.6	4.2	0.4	5.04	117.95	0.017
1						
2						
3						

Precautions:

1. Take care that there is no air bubble entrapped in the apparatus when noting manometer reading.
2. There should be no leakage from any of the pipe fittings.

Video Links for experiment:
https://youtu.be/f83D4h2LN4I

PIPE FRICTION SAMPLE READINGS

Observation Table:

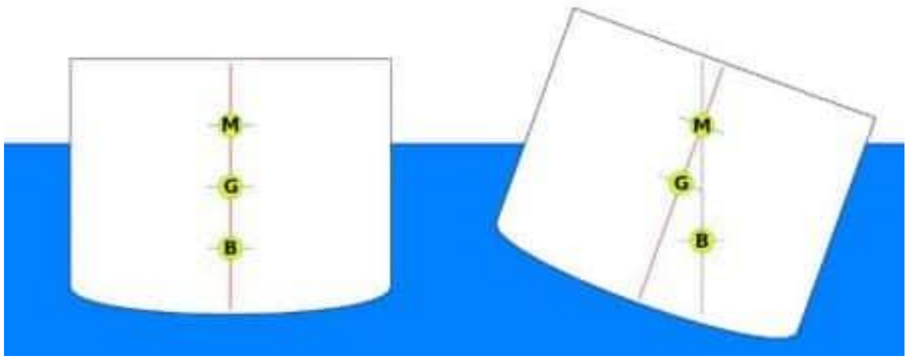
S. NO.	MEASUREMENT TANK READING				Discharge actual $Q_{act} = \frac{A(h_2 - h_1)}{t} cm^3 / \sec$
	Initial level Cm h1	Final level Cm h2	h2 - h1	Time t sec	
. Reading for 2.5 Cm dia pipe					
1	2	12..0		15.50	
2	2.5	12.5		18.31	
. Reading for 1.5 Cm dia pipe					
1	3.0	13.0		58.36	
2	3.0	13.0		26.85	
3	3.0	13.0		24.00	

S. NO.	Manometer Difference R cm of Hg			$h_f = R(\frac{\rho_m}{\rho_f} - 1)$ $h_f = R(\frac{13.6}{1} - 1)$ $h_f = R \times 12.6 cm$ of H_2O	Velocity of water $V = \frac{Q}{a}$	$F = \frac{2gdh_f}{LV^2}$
	h_1	h_2	R = $h_2 - h_1$			
. Reading for 2.5 Cm dia pipe						
1	4.7	4.2				
2	3.1	4.0				

. Reading for 1.5 Cm dia pipe						
1	2.5	4.0				
2	1.1	5.9				
3	0.9	6.7				

Experiment No.6

Metacentric Height



Objective:

Experimental determination of metacentric height of a ship model .

A point about which a floating body tries to oscillate is called the metacenter of that body. The distance between metacenter (M) and the center of gravity (G) of the floating body is known as metacentric height (GM).

Metacentric height of a floating body can be found using the following formula:

GM = m.x/ W tan θ

Where, GM = Metacentric height

m_1 = Additional weight added

x = Distance of w_1 from center

W = Weight of floating ship

θ= Angle of Heel

Determination of Metacentric Height

Apparatus Required

Following are the apparatus required to measure the metacentric height of a floating body.

- A Tank
- A Floating Ship which contains horizontal beam at its middle and a movable pointer on a graduated scale at the center of horizontal beam.
- Weights

Test Procedure

Test procedure to find metacentric height of a floating body is as follows:

- Take an empty tank and fill it with water up to 2/3rd of its height and note down the height of water level (Z_1).
- Now place the floating ship in the tank and note down the rise in the water level (Z_2).
- Adjust the floating ship in such a way that the pointer should show zero reading on the graduated scale.
- After adjusting, add weight (w_1) to the horizontal beam of floating ship at a known distance (Y) from the center of the beam.
- Now the ship will tilt at some angle on one side and observe the tilt angle ongraduated scale and note it down.
- Repeat the same procedure for 4 more times by keeping the load constant and varying the distance or by keeping the distance constant and varying the load.
- In this case, distance is kept constant as (x) and weight is varied.
- Finally, calculate the metacentric height using the given formula.

Result

Metacentric Height of Floating Body, GM =

Video link for experiment:
https://www.youtube.com/watch?v=60O0cyScRmk

SAMPLE READINGS FOR METACENTRIC HEIGHT OF A SHIP MODEL

A. Under unloaded condition

S.No.	W (grams) (empty ship)	X (cms.)	θ (degrees)	m (grams)	MG (cms.) = m.x/ W tan θ
1	2015	17.0	7.0	108	
2	2015	17.0	14.0	208	
3	2015	17.0	5.0	108	
4	2015	17.0	12.0	208	

B. Under Loaded condition

S.No.	W (grams) (empty ship+Load)	X (cms.)	θ (degrees)	m (grams)	MG (cms.) = m.x/ W tan θ
1	2015+529	17.0	5.0	206	
2	2015+529	17.0	10.0	314	
3	2015+529	17.0	6.0	206	
4	2015+529	17.0	12.0	314	

<u>EXPERIMENT No. 7 :</u>

RED WOOD VISCOMETER

<u>Objective:</u> To calculate viscosity of given oil using Red Wood Viscometer.

<u>Theory/Principle:</u> Viscometer is an instrument which, is used to measure viscosity of lubricating oil. The quantity measured is equally the time taken to pass a constant volume of liquid through orifice fitted at one bottom of viscometer.

<u>Description:</u>

Red wood viscometer is commonly used for determining viscosity of thin lubrication oil. It has a jet at bore 1.62mm and length 10mm.

It consists of following parts:

a. **Oil cup:** It is silver plate and brass cylinder the upper end of the cup is open the bottom of one cylinder is fitted with a jet. It is open or closed by a valve rod.
b. **Heating bath:** Oil cup is surrounded by cylindrical copper bath containing water. It is provided with top to emptying water from it. And long side tube projecting outward.
c. **Stirrer:** Outside the oil cylinder a stirrer carrying & blades is provided with circular stields at the top to prevent any water splashing into oil cylinder.
d. **Spirit Level:** The lid of the cup is provided with a spirit level for vertical leveling of the jet.
e. **Levelling Screw:** The entire jet on the Legs provided at their bottom with leveling screws.

Working Procedure:

a. Clean the oil cap place the ball off valve Rod and on gate i.e. close the jet.
b. Then after oil is free from any suspension partical is filled in the cap up to a particular level.
c. An empty flask is kept just below the gate.
d. Then after note the temp. With the help of a thermometer.
e. Valve rod is lifted.
f. The time taken for some of oil to collect in the flash is noted.
g. Finally the result is expressed in seconds of particular temp.

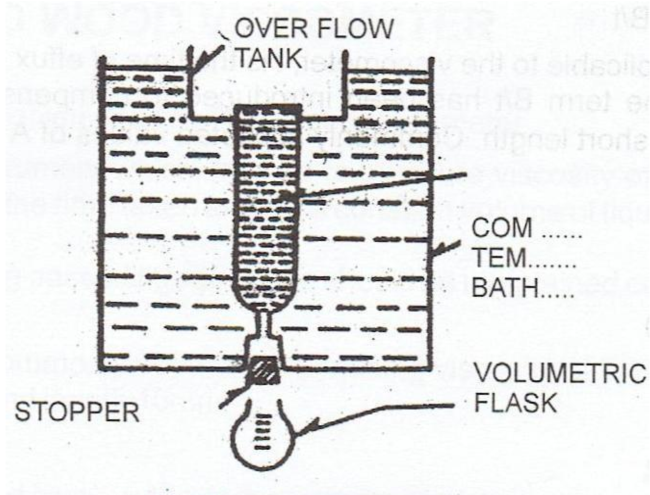
The velocity in the Engler, Redwood and Saybolt degrees can be converted into kinematics visit V by the empirical relation

$$V = A_t - B/t$$

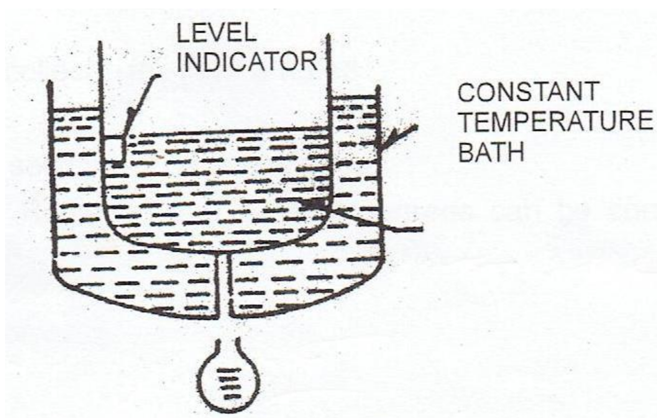
Where A and B are constants applicable to the viscometer, t is the time efflux in seconds and V is the kinametic viscosity in stokes. The term B/t has been introduced to compensate for adequate flow development in case of a tube of short length. Commonly accepted values of A and B for the different viscometers are:

VISCOMETER	**A**	**B**
Say bolt	0.24	190
Redwood	0.26	172
Engler	1.47	374

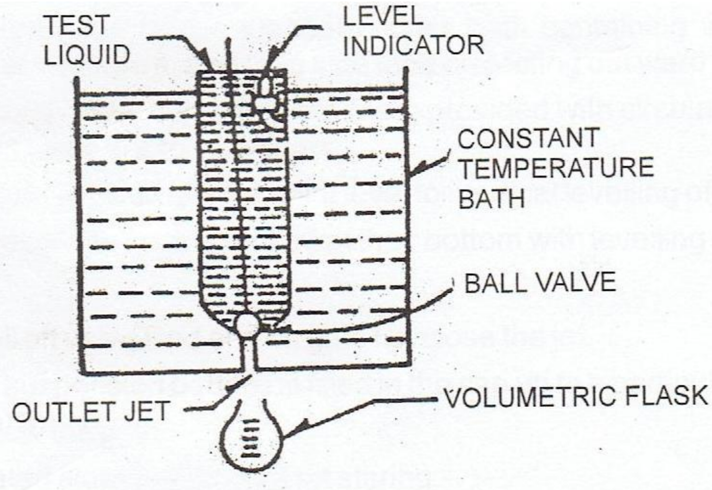
These laboratory instruments are widely used in the petroleum and allied industries.



(A) SAYBOLT VISCOMETER



(C) ENGLER VISCOMETER



(B) RED WOOD VISCOMETER

Experiment No. 08

PELTON WHEEL TURBINE TEST RIG

AIM: To conduct load test on pelton wheel turbine and to study the characteristics of pelton wheel turbine.
.

APPARATUS REQUIRED:

1. Venturimeter
2. Stopwatch
3. Tachometer
4. Dead weight

DESCRIPTION:

Pelton wheel turbine is an impulse turbine, which is used to act on high loads and for generating electricity. All the available heads are classified in to velocity energy by means of spear and nozzle arrangement. Position of the jet strikes the knife-edge of the buckets with least relative resistances and shocks. While passing along the buckets the velocity of the water is reduced and hence an impulse force is supplied to the cups which in turn are moved and hence shaft is rotated.

PROCEDURE:

1. The Pelton wheel turbine is started.
2. All the weight in the hanger is removed.
3. The pressure gauge reading is noted down and it is to be maintained constant for different loads.
4. The Venturimeter readings are noted down.
5. The spring balance reading and speed of the turbine are also noted down.
6. A load is put on the hanger, similarly all the corresponding readings are noted down.
7. The experiment is repeated for different loads and the readings are tabulated.

GRAPHS:

η %							

The following graphs are drawn.

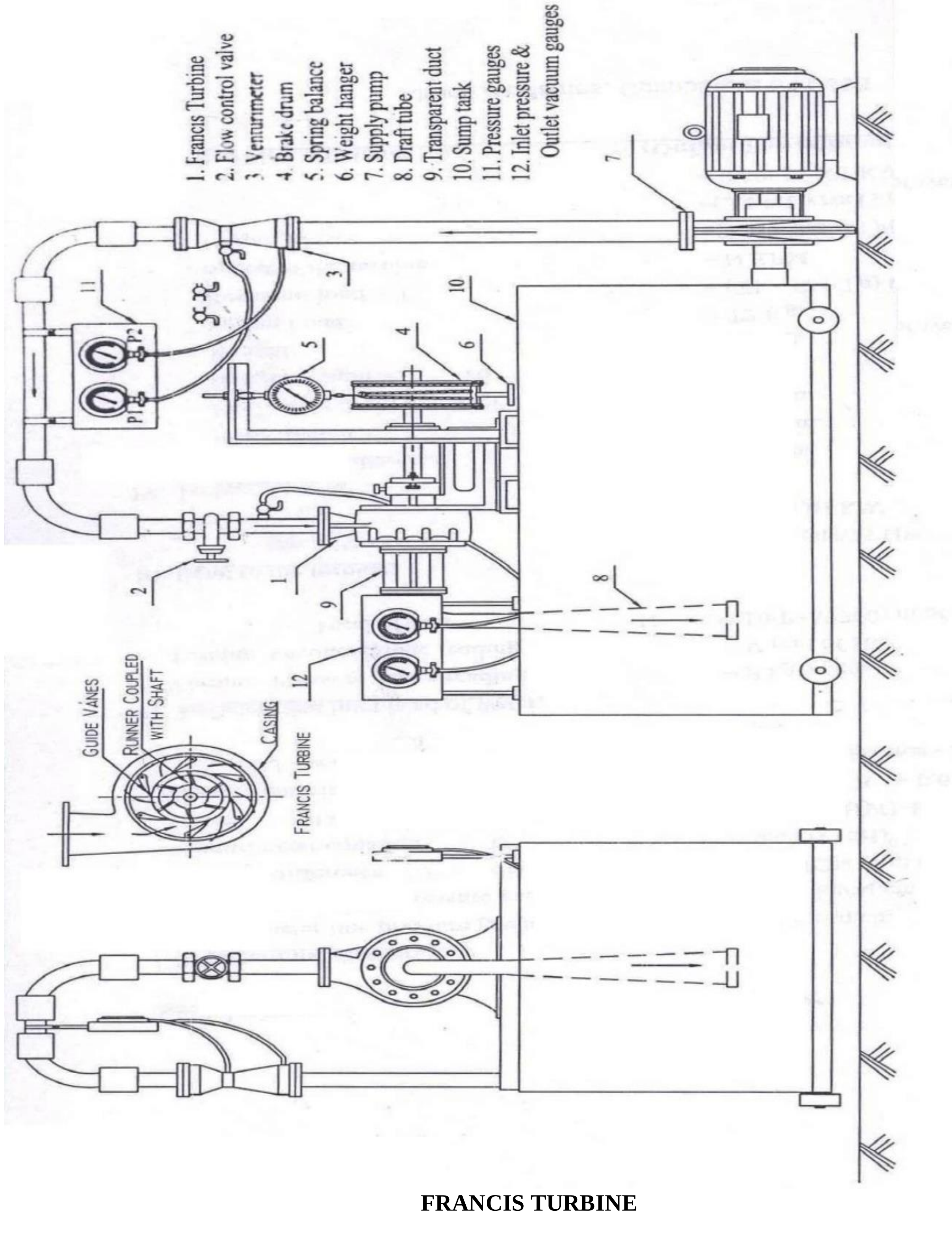
1. BHP Vs IHP
2. BHP Vs speed
3. BHP Vs Efficiency

S.No	Pressure Gauge Reading [Hp] Kg\cm2	Total Head [H] m of water	Venturimetr reading Kg/cm		H = (P1-P2) x 10 m of water	Weight of hanger To Kg	Speed of turbine N Rpm	Weigh of hanger [T1] kg	Spring Balance T2 Kg	Tension [T] Kg	Discháre Q x10-3 m3/sec	B.H.P hp	I.H.P hp
			P1	P2									
												Mean =	

MODEL CALCULATION:

RESULT:

Thus the performance characteristic of the Pelton Wheel Turbine is done and the maximum efficiency of the turbine is ………. %



FRANCIS TURBINE

Sample Readings for Pelton Turbine

S.No.	Pressure Gauge Reading Kg/cm^2	Manometer Readings (P1-P2) mm of Hg	RPM	Tight side Tension T1(Kg)	Slack side Tension T2 (Kg)
1.	2.75	2.5	488	1.0	0.18
2.	2.67	3.5	495	1.8	0.30
3.	2.53	4.5	502	1.9	0.20
4.	2.40	5.0	525	2.3	0.40
5.	2.65	7.5	570	2.3	0.30
6.	2.15	8.0	600	2.4	0.40

Venturimeter Inlet Dia. = 50mm

Venturimeter Throat Dia = 38mm

Effective radius of Break Drum = 270mm

Belt Thickness = 06mm

Cd of Venturimeter = 0.97

EXPERIMENT NO.9

REYNOLDS EXPERIMENT

Objective:- To perform the Reynolds experiment for determination of different regimes of flow.

Theory: - The flow of real fluids can basically occur under two very different regimes namely laminar and turbulent flow. The laminar flow is characterized by fluid particles moving in the form of lamina sliding over each other, such that at any instant the velocity at all the points in particular lamina is the same. The lamina near the flow boundary move at a slower rate as compared to those near the center of the flow passage. This type of flow occurs in viscous fluids, fluids moving at slow velocity and fluids flowing through narrow passages.

The turbulent flow is characterized by constant agitation and intermixing of fluid particles such that their velocity changes from point to point and even at the same point from time to time. This

type of flow occurs in low density Fluids flow through wide passage and in high velocity flows.

Reynolds number is defined as, the ratio of inertia force to the viscous force .Where viscous force is shear stress multiplied area and inertia force is mass multiplied acceleration.

$$Re = \frac{VD\rho}{\mu} = \frac{VD}{v} \qquad (v = \mu\rho\ )$$

Where

Re-Reynolds number

V - Velocity of flow

D - Characteristic length=diameter in case of pipe flow = 25mm

P - Mass density of fluid =1000

μ - dynamic viscosity of fluid = 1.0016×10^{-3} Pa/s

Reynolds observed that in case of flow through pipe for values of <u>Re<2000</u> the flow is laminar while offer <u>Re>40000</u> it is turbulent and for <u>2000<Re<4000</u> it is transition flow.

Description:-

A stop watch, a graduated cylinder, and Reynolds apparatus which consists of water tank having a glass tube leading out of it. The glass tube has a bell mouth at entrance and a regulating valve at outlet, a dye container with an arrangement for injecting a fine filament of dye at the entrance of the glass tube. Potassium permanganate (to give brightly reddish color streak) thermometer and measuring tank.

Procedure:

Start the experiment by pressing start button with default values of temperature of water and time taken and diameter of pipe. Then pass the experiment with few cycles and note the observation.

Observation1:

1) Start the experiment and allow the water to flow in to the tank of the apparatus. Water level in the pyrometer is slightly rising along with rise in tank. Control valve of the glass tube should be slightly opened for removing air bubbles.

2) After the tank is filled outlet valve of the glass tube and inlet valve of the tank should be closed, so that water should be at rest.

Observation2:

1) Keeping the velocity of flow is very small and inlet of the die injector is slightly opened, so that the die stream moves at a straight line throughout the tube showing the flow is laminar.

2) Again measure the discharge and increase the velocity of flow.

Observation3:

1) Note the observations till the die stream in the glass tube breaks up and gets diffused in water.

2) Repeat the experiment by decreasing the rate of flow and by changing the temperature and diameter of pipe.

Observation Table:-

Inner diameter of glass tube, D = 0.025m

Cross - sectional area of glass tube, $A = \frac{\pi}{4}D^2$

Mean temperature of water – t - = 20^0 c

dynamic viscosity of fluid = 1.0016×10^{-3} Pa/s

Kinematic viscosity of water-ν- =

S.No	Volume collected in measuring flask (in ML)	Time taken 't' in (sec)	Discharge 'Q' in (m^3/sec)	Velocity 'V' (m/sec)	Reynold's Number 'Re'	Type of flow
1	300	20				
2	300	12				
3	300	08				
4	300	05				
5	300	03				

Calculation:-

2) Discharge – Q= Volume/time

3) Velocity of flow – V = Q/A

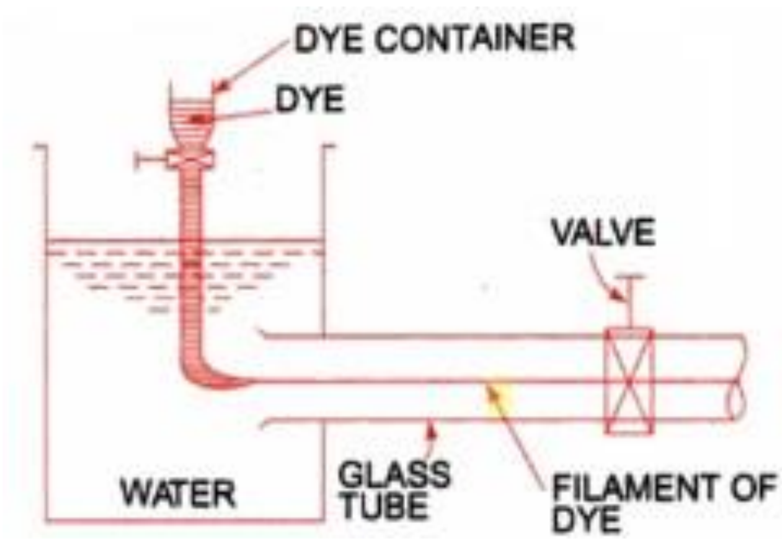
Where A is the cross section area of pie in m sq.

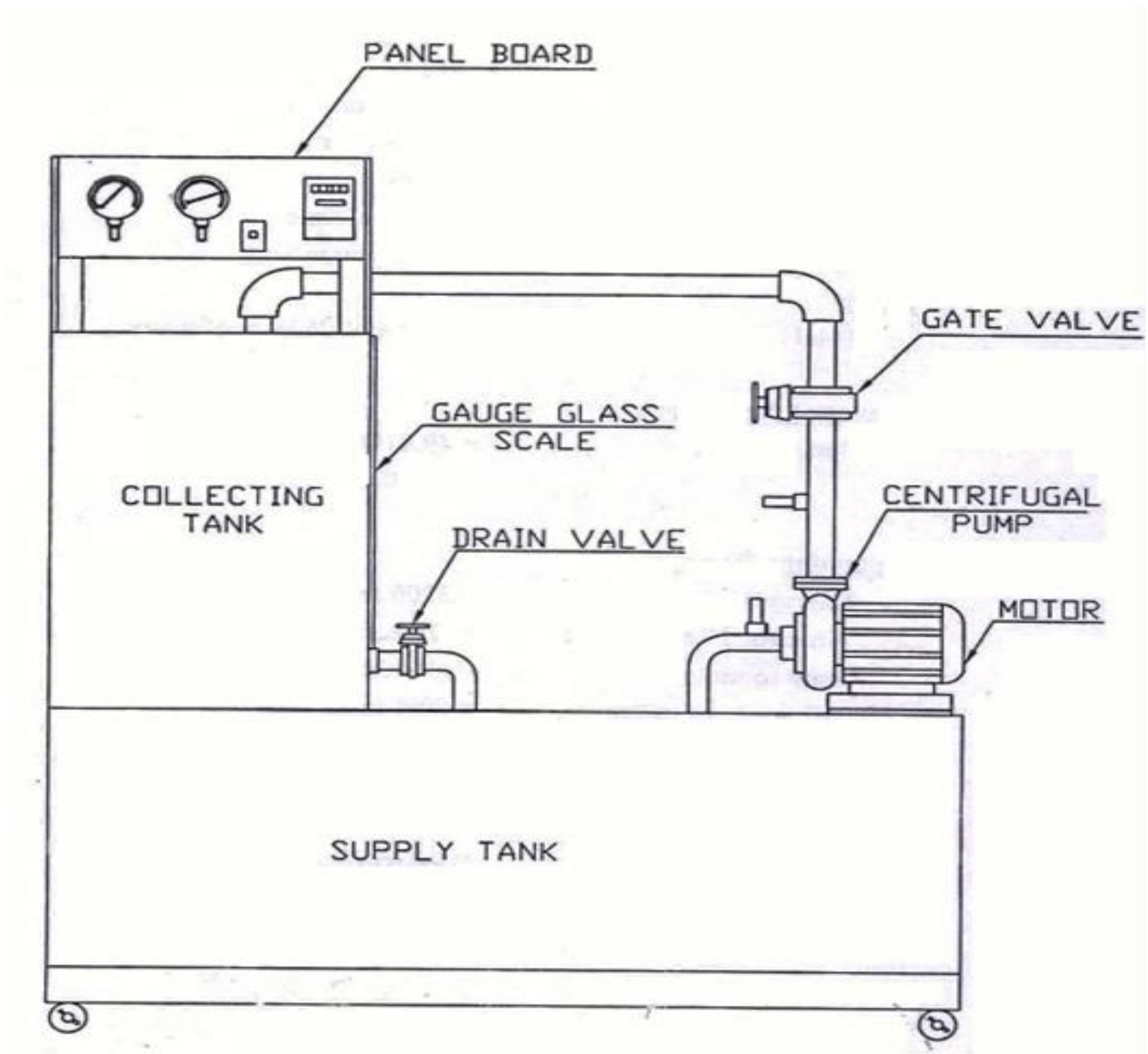
Results: -

1. Reynolds number –Re = VD/ ν

2. Regime of flow =

Conclusion:-





CENTRIFUGAL PUMP TEST RIG

Experiment No. 10

AIM: To study the performance characteristics of a centrifugal pump and to determine the characteristic with maximum efficiency.

APPARATUS REQUIRED:

1. Centrifugal pump test rig
2. Stop watch

FORMULAE:

1. ACTUAL DISCHARGE:

$$Q\ act = A \times 0.1 / t\ (m^3 / s)$$

Where:

A = Area of the collecting tank (M^2)

t = Time taken for 10 cm rise of water level in collecting tank.

2. TOTAL HEAD:

$$H = H_d + Hs + H_f$$

Where:

H_d = Discharge head, meter

H_s = Suction head, meter

H_f = Frictional head, meter = 03 m

3. INPUT POWER:

$$I/P = (3600 \times N \times 1000) / (E \times T)\ (watts) \times 0.6 \times 0.6$$

(Taking Efficiencies of Electric Motor and Transmission system 60% each)

Where:

N = Number of impulses of energy meter LED

E = Energy meter constant (imp. / Kw hr) = 3200 imp./kw/hr.

T = time taken for 'N' impulses (seconds)

Suction gauge Hs m of water	Suction head H\m of water	Delivey Gauge Readin g(hd) m of water	Deliver y Head (Hd) m of water	Total Head (H) m of water	Time taken for „h" rise of water (t) S	Time taken for Nr revolut ion t S	Actual Discharge (Qact) $x10^{-3}$ m^3\sec	Input Power (Pi) watt	Output Power (Po) watt	% η
Average =										

S.No						

4. OUTPUT POWER:

$$P_o = \rho \times g \times Q \times H \text{ (watts)}$$

Where,

ρ = Density of water (kg / m³)
g = Acceleration due to gravity (m / s^2)
H = Total head of water (m)

5. EFFICIENCY:

$$\eta_o = (\text{Output power o/p / input power I/p}) \times 100\ \%$$

Where,

O/p = Output power kW
I/ p = Input power kW

DESCRIPTION:

PRIMING:

The operation of filling water in the suction pipe casing and a portion delivery pipe for the removal of air before starting is called priming.

After priming the impeller is rotated by a prime mover. The rotating vane gives a centrifugal head to the pump. When the pump attains a constant speed, the delivery valve is gradually opened. The water flows in a radially outward direction. Then, it leaves the vanes at the outer circumference with a high velocity and pressure. Now kinetic energy is gradually converted in to pressure energy. The high-pressure water is through the delivery pipe to the required height.

PROCEDURE:

1. Prime the pump close the delivery valve and switch on the unit
2. Open the delivery valve and maintain the required delivery head
3. Note down the reading and note the corresponding suction head reading
4. Close the drain valve and note down the time taken for 10 cm rise of water level in collecting tank
5. Measure the area of collecting tank
6. For different delivery tubes, repeat the experiment
7. For every set reading note down the time taken for 5 revolutions of energy meter disc.

GRAPHS:

1. Actual discharge Vs Total head

2. Actual discharge Vs Efficiency
3. Actual discharge Vs Input power
4. Actual discharge Vs Output power

MODEL CALCULATION:

RESULT:

Thus the performance characteristics of centrifugal pump was studied and the maximum efficiency was found to be ______________

Sample Readings for Centrifugal Pimp test Rig

S.No.	Discharge Pressure (Kg/cm^2)	Time taken for 10.0 cm water level rise in collection tank (sec.)	Time for 10 blinks of energy meter (sec.)
1.	0.35	5.65	20.9
2.	0.47	6.37	22.12
3.	0.57	8.22	23.06
4.	0.65	12.68	26.72

Friction Head = 3.0 m

Collection Tank Cross section = 25x40 cm

Suction Head = 0.0 m (Nil)

Energy meter Calibration = 3200 impulses/kw/hr.

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